Chapter 5
Construction and Postconstruction Activities

5-1. Objectives

a. General. The objectives of this chapter are to provide guidelines for activities to be undertaken during and following the construction of a beach stabilization project. These activities include documentation of construction records, new or unusual construction techniques, construction problems encountered and their solutions, necessary design modifications (to provide as-built information), and periodic postconstruction inspections. The requirements for the preparation of an "Operations and Maintenance Manual" for use by local sponsors in operating the project are also presented. In addition, postconstruction monitoring may be undertaken to evaluate a project's functional and structural performance with the aim of developing guidance and methodology for the design of similar type projects in the future.

b. Requirements and guidance. Specific performance requirements and guidance for accomplishing the satisfactory maintenance and operation of shore protection works, including coastal structures and beach-fill projects, are provided in ER 1110-2-2902. This regulation prescribes operations, maintenance, inspection, and record keeping procedures required to obtain the intended purposes of shore protection projects. According to ER 1110-2-2902, the Corps, while not responsible for the maintenance of shore protection projects, is involved in the periodic reconstruction or nourishment of such projects. The Federal participation is conditioned on the non-Federal interest assuring operation, maintenance, replacement, and repair of improvements during the economic life of the project as required to serve the intended purposes.

5-2. Construction Records

During construction of a beach stabilization project a daily log should be maintained by the Corps of Engineers' inspector. Items such as the construction techniques used and problems encountered along with their solutions should be noted. New, unique, and innovative construction practices should be documented along with an assessment of their success. In addition to information relevant to the project under construction, information that might be useful for the design and/or construction of future projects should be noted. A photographic history of construction with documentation giving dates and locations of the photographs and what is being illustrated should be maintained. Changes that deviate from the original design must be documented to provide an as-built record of the project. Project drawings should be marked up and revised to show the as-built conditions. It is also important that the design engineer conduct periodic site visits during project construction.

5-3. Inspections

Following construction, and for the lifetime of the project, periodic inspections of the project should be conducted. The frequency of inspection will depend on the type of project, the physical environment at the site, and the scope of the project. Annual inspections of projects involving beach fill should be made since significant beach changes can occur over a single storm season. In addition, inspections should be made following severe coastal storms. Inspections should focus on potentially dangerous conditions; conditions that can compromise the public safety, such as hazards to swimmers or navigation, must be identified so that remedial measures can be promptly taken. Structural deterioration that impairs a project's ability to function or that imperils the structure itself should be noted. Repairs that may prevent unraveling of the structure should be made in a timely manner. Photographic documentation should be provided if appropriate. Shoreline and\or bathymetric changes that may be precursors of a functional or structural failure should also be identified. For example, scour at the toe of an offshore breakwater, groin, or seawall may indicate imminent collapse and failure.

5-4. Monitoring

a. Functional performance. Monitoring the functional performance of a beach erosion control project may serve two purposes: to identify deficiencies in the performance of the project so that modifications can be made to improve its performance (operational monitoring), or to evaluate the adequacy of design methods used and, if necessary, to improve them (research monitoring). The design of beach erosion control structures is not an exact science. The marine environment is harsh; it is corrosive, abrasive, and subject to unpredictably severe and unusual storms. Even the best designs are usually based on insufficient and/or inadequate data. Annual average wave conditions and sediment transport rates can change significantly from year to year making the design of beach erosion control structures difficult. It is not unusual for projects to be modified during their lifetime to improve their performance based on observations of their behavior. Likewise, design methods for beach erosion control projects are evolving; they are being modified and improved as experience with prototype projects is gained. Monitoring completed projects can provide the data needed to improve design guidance. These improved methods will lead to better, more cost-effective projects in the future. Each project monitoring program will need to be individually developed since each project is unique and has site-specific conditions that must be evaluated and documented. Also, the objectives of a monitoring program will differ from project to project. The following discusses several types of basic data that are often included in beach stabilization project monitoring programs. In addition to data collection, data analysis methods must be considered in the monitoring plan and entered into the monitoring budget.

(1) Photographic documentation. An easy and relatively inexpensive way to monitor performance of a beach erosion control project is to obtain periodic photographs of the project. An inexpensive procedure is to periodically obtain ground-level photographs of the same scene taken from the same location. While this method gives a history of project performance, it is mostly just qualitative. Quantitative data can be obtained from controlled, vertical aerial photography of a project area. Data on ground elevation, shoreline and berm location, offshore shoals, structure geometry, and deterioration can all be obtained from aerial photographs. In addition, beach-use and land-use changes can also be monitored. Aerial photographs should have an appropriate scale; a 1:4800 (l inch = 400 feet) scale generally provides sufficient detail and is typically used for coastal project monitoring. Photographs are usually 9- by 9-inch contact prints of color or black and white negatives (Figure 5-1). Larger scales (usually enlargements of 9- by 9-inch negatives) have also been found useful for specific applications, e.g. monitoring the movement of rubble-mound structure armor between successive photographic flights. Adjacent aerial photographs should have a 60-percent overlap so that they can be analyzed stereographically to obtain ground elevations. The frequency of photography depends on the purpose of the monitoring. If the purpose is inspection, annual flights may suffice; if the purpose is detailed monitoring of project performance, quarterly, monthly, or more frequent flights may be necessary.

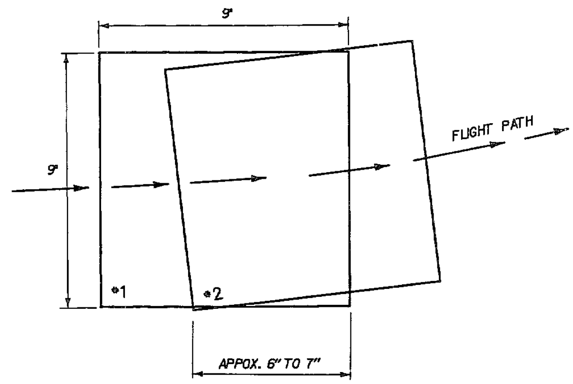

Figure 5-1. Typical 9- by 9-inch aerial photography showing 60-percent overlap (schematic)

(2) Beach profiles and bathymetric changes.

(a) The design objective of a stabilization project is to maintain a wide beach; consequently, the best indicator of a project's success or failure is the condition of the beach. Beach profiles, obtained periodically, can document the accretion, erosion, or stability of the project's shoreline. The frequency of beach surveys depends on the objectives of the monitoring program. If the monitoring is operational or the objective is to develop design methods and/or document transient phenomena such as performance immediately following construction or poststorm recovery, quarterly, monthly, or even more frequent surveys should be conducted. The quality and detail will depend on the purpose. It is important to note that monitoring will not only assist with routine evaluation of the project but may significantly assist in documenting storm damages or damages prevented.

(b) The spacing along the beach of profile lines will also depend on monitoring objectives. If only general shoreline trends are needed, distantly spaced profiles may suffice, i.e., if one or two profiles can be assumed to describe conditions and changes occurring over a relatively long stretch of beach (Figure 5-2). In contrast, if calculations of accretion and\or erosion volumes are needed or if seasonal volume changes need to be documented, profile lines must be spaced close enough to allow reasonably accurate volume computations. At a minimum, there should be at least three profile lines within a groin compartment, spaced at the most several hundred feet apart. Similarly, there should be three or more profile lines in the lee of a detached breakwater depending on the breakwater's length, distance from shore, etc. (Figure 5-3). In some cases, subaerial profile changes will provide sufficient information. For example, if changes only in the location of the berm or the low-, mean-, or high-tide level shorelines are needed, subaerial or, at most, wading surveys will suffice. On the other

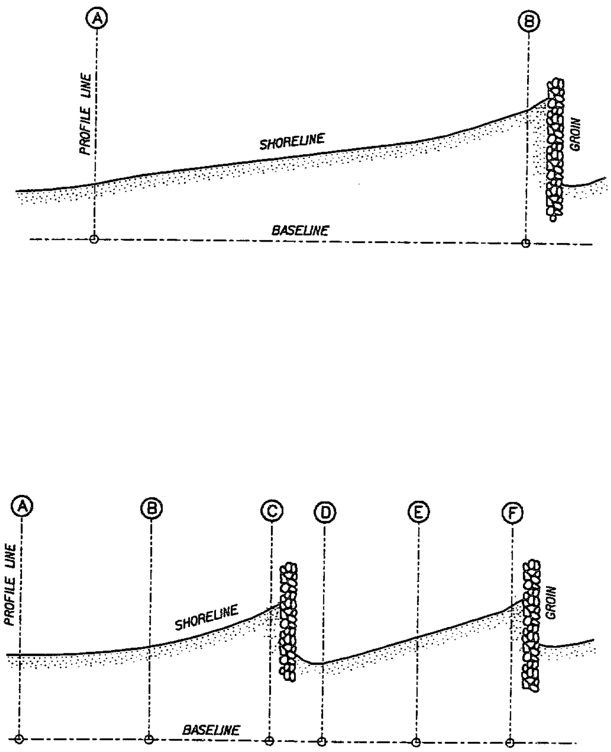

Figure 5-2. Spacing of profile lines where beach changes are gradual and severe

hand, if bathymetric changes brought about by project construction or seasonal offshore profile changes are to be documented, profile lines will have to extend offshore beyond wading depth. Cost is often a factor. Subaerial profiles are relatively inexpensive to obtain whereas profiles extending some distance offshore are more costly. The two surveys (subaerial and subaqueous) must be matched, usually in the surf zone where changes are large and where they occur quickly. Thus, subaerial and corresponding subaqueous surveys must be done within a short time of each other with no intervening storms.

(3) Wave conditions.

(a) Waves and the longshore currents they cause are the dominant sediment moving forces in the nearshore zone. Waves also cause the critical forces that act on coastal structures. Thus, wave data are needed to establish cause and effect relationships involved in the performance of beach erosion control projects.

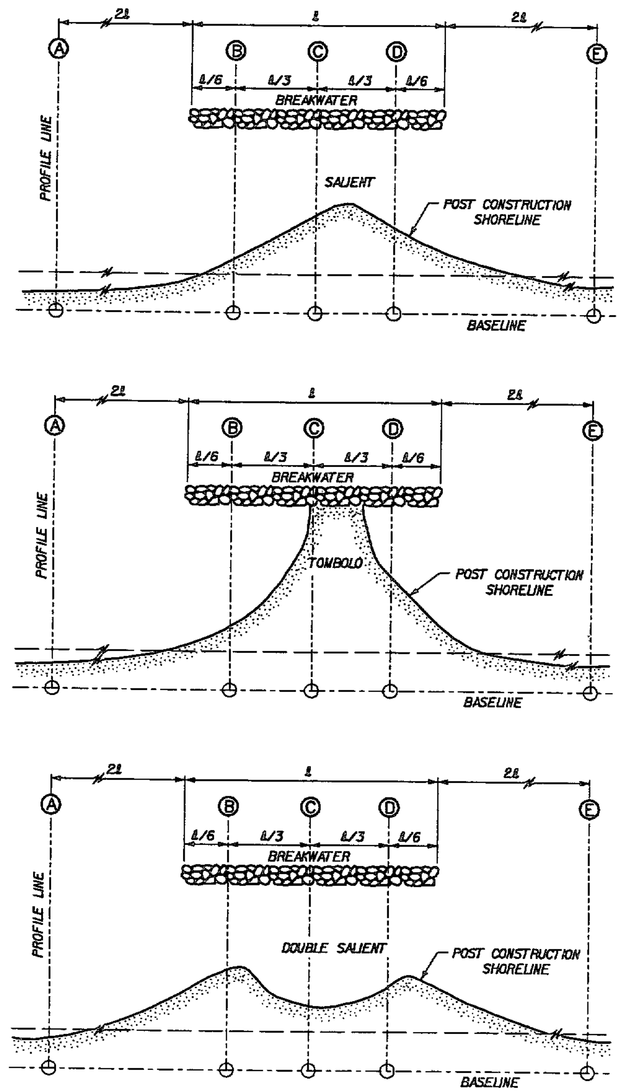

Figure 5-3. Spacing of profile lines in the lee of a detached breakwater

(b) The deployment and operation of wave height and/or wave height and direction recording instruments may be justified for more detailed research monitoring programs where the cause and effect relationships between waves, resulting sediment transport, and project performance need to be established. Various types of gages are available, selection of which will depend on the type of wave data needed and the physical conditions at the site where the gage will be used. For sediment transport studies, a wave measuring system that provides information on wave direction is often needed. This usually requires the deployment of two or more wave gages or the measurement of water particle velocities in addition to wave height or subsurface pressure. If only wave height is needed, an accelerometer buoy, subsurface pressure gage, or surface piercing gage will suffice. Wave gage selection, installation, operation, signal processing, and data analysis usually require the assistance of qualified personnel.

(c) An inexpensive alternative to wave gages is to employ coastal observers who can make daily observations of wave, wind, and nearshore current conditions. The CERC's LEO program (Schneider 1981) is an example. Under the LEO program, volunteers make daily observations of breaking wave heights, breaker periods, and the angle that incoming wave crests make with the shoreline. In addition, they obtain data on longshore current velocity, surf zone width, foreshore beach slope, and wind speed and direction. A disadvantage is that the data depend critically on the diligence and skill of the observer. Thus, data quality varies from observer to observer and possibly from day to day for a given observer. It is often for storm conditions when wave data are critically needed that volunteer observers are unable or unwilling to make observations. The quality of some elements of the LEO data set is better than others, and careful interpretation of the data is important. Interpretations and conclusions drawn from the data must recognize the limitations of the measurements. Wave observation sites must be carefully selected to avoid locations where conditions may not be representative of an area. This is true for visual observation sites as well as for wave gage sites. On the other hand, wave measurements may be desired in sheltered areas for some applications; for example, wave measurements behind a nearshore breakwater will determine wave attenuation characteristics of the structure.

b. Structural performance. Structural performance and functional performance are closely related. When a project fails structurally, it often loses its ability to function. The extent of a structural failure determines the extent of any associated functional failure. Some structures, such as rubble-mound structures, can experience a certain level of damage without total loss of functioning ability. These structures fail progressively rather than catastrophically, and they are considered "flexible." Other structures, such as bulkheads and seawalls, cease to function following a structural failure. The failure of this type of structure is more rapid than progressive, and they are considered "rigid." Like functional performance monitoring, two types or levels of structural monitoring can be undertaken. Structural monitoring can be performed to simply establish if a given structure has sustained damage so that repairs might be made in a timely manner (operational monitoring), or it can be performed to obtain data to improve design methods (research monitoring). Operational monitoring might involve only little more than periodic inspections, whereas research monitoring might involve more elaborate wave and wave force measurements.

(1) Photographic documentation.

(a) A relatively inexpensive way to document structural performance is to periodically inspect the structure and photograph areas of structural deterioration. Photographs should be accompanied with a written description of the damage, an indication of where on the structure the damage is located, and its probable cause. The location can be indicated on appropriate project drawings and\or on a project map. Aerial photographs can also be used to get an overall picture of structural damage, particularly damage surveys of rubble-mound structures following major storms. Aerial surveys have the added advantage of affording access to what might otherwise be an inaccessible area.

(b) For more detailed research monitoring, controlled, vertical, aerial photographs can be used to obtain quantitative data on rubble armor unit movement or on the lateral displacement of other structures. Large-scale stereographic pairs of photographs can provide information on changes in the elevation of structural components, such as armor units. A reference set of photographs taken shortly after construction can serve as a base condition against which subsequent photographs can be compared.

(2) Wave conditions.

(a) Data on wave conditions are needed to determine the conditions under which structural damage or failure may have occurred or to correlate with wave force measurements. Recorded wave data, however, are generally not obtained under routine operational structure monitoring because of the high cost of obtaining it. Rigid structures such as sheet-pile groins are usually designed for high waves in the spectrum (the l-percent wave or higher), and design wave conditions are selected with a return period of many years. Unless wave conditions exceed design conditions, damage and failure will probably not occur.

(b) Rubble-mound structures are designed for lower waves in the spectrum (usually the 10-percent or significant wave) and for wave conditions with a relatively low return period since they can sustain some damage without failing functionally. Wave gages are sometimes deployed for the research monitoring of rubble-mound structures. Large waves associated with storms are of primary interest since they result in armor unit displacement and other damage. Wave direction information is usually of secondary importance for structural monitoring, and a single wave buoy, subsurface pressure gage and\or surface piercing gage usually suffices.

(c) If they can be obtained, LEO data can provide an inexpensive alternative source of wave information. Data are usually needed for storm waves, and it may not be possible for an observer to obtain wave height estimates under storm conditions. If data can be obtained, their accuracy may be suspect.

(3) Wave force measurements. Wave force and\or pressure measurements on rigid beach erosion control structures may be desired for research monitoring purposes. In conjunction with the force or pressure measurements, wave height data at the structure would have to be obtained to develop correlations. Wave force or pressure data, however, are not usually obtained under routine monitoring.

5-5. Operations and Maintenance Manual for Local Sponsors

a. Requirements. ER 1110-2-2902, "Prescribed Procedures for the Maintenance and Operation of Shore Protection Works," requires that an Operation and Maintenance (O&M) manual be prepared for local sponsors of federally constructed shore protection works who are responsible for operating and maintaining such projects. The Federal government, however, must provide local sponsors with an O&M manual containing guidance on how to operate the project in a way to achieve project objectives. This responsibility requires that a certain level of project monitoring be undertaken to obtain data on which operational decisions can be made. The local sponsor must identify a "superintendent" in charge of operating the project who must prepare an emergency plan to respond to storms exceeding the project's design storm so as to minimize any threat to life and property. He will maintain organized records on the operations, maintenance and repair, condition, inspection, and replacement of the project's elements including any structures and beach fills. The O&M manual and, therefore, any operations monitoring plan should address the four elements of a shore protection project: the beach berm and foreshore, the protective dune, coastal structures, and any appurtenant facilities. The monitoring requirements of ER 1110-2-2902 should be viewed as minimum monitoring requirements.

b. Poststorm condition surveys. Regarding coastal structures, ER 1110-2-2902 requires that poststorm condition surveys be made of any structures to include the identification of seepage areas, piping or scour beneath or through the structures, settlement that might affect stability, condition of the materials of which the structure is built, identifying conditions such as concrete spalling, steel corrosion, encroachment on the structure that might endanger the structure or affect its functional performance, accumulation of trash and debris; bank scour; toe erosion; flanking erosion; drainage systems; the condition of any mechanical/electrical systems such as pumps, navigation lights, etc.; and assurance that no boats or floating plant are tied up to the structures.